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Effect of Moisture Conservation Practices on Yield and Water Use Efficiency (WUE) of Direct Seeded Rice - Greengram Cropping Sequence in *Rainfed* Ecosystem of Assam

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ABSTRACT: In India, the development issue of *rainfed* agriculture assumes critical importance as it covers about 56% of total cultivated area of the country. The conventional method of rice cultivation with irrigation is at threat due to declining availability of water. A field experiment on sandy loam soil was conducted during *autumn* and *kharif* season of 2016 and 2017 at Biswanath College of Agriculture, Assam Agricultural University, Biswanath Chariali to study the effect of moisture conservation practices in terms of land configuration and residue management on yield performance and water use efficiency (WUE) in direct seeded rice-greengram cropping sequence. The experiment was conducted in RBD with six moisture conservation practices (flatbed with crop residue incorporation, flatbed without crop residue incorporation, broad bed furrow (BBF) 60-30 cm with residue incorporation, BBF 60-30 cm without residue incorporation, BBF 120-30 cm with residue incorporation and BBF 120-30 cm without residue incorporation) with 4 replications. The yield attributes, seed and stover yield (q ha^{-1}) of both the crop viz. direct seeded rice and green gram were better in BBF as compared to flatbed method of moisture conservation. Among the BBF, the crop residue incorporated treatments performed better over no residue incorporation. The total water use (mm) was 2.76% higher and WUE was 2.45% higher in the moisture conservation practices of BBF with residue incorporation irrespective of size of the bed over flat beds with residue incorporation treatments. The equivalent yield of the direct seeded rice-greengram system was 24.62% higher in BBF irrespective of the bed size over flatbed and between the bed size of 60-30 cm and 120-30 cm. BBF of 120-30 cm size bed showed comparatively higher net return of Rs. 30,598/ha with a B:C ratio of 1.69.

Key words: BBF, direct seeded rice, grain yield, net return

Introduction

More than half of the world's population depends primarily on rice as a staple food and India is the world's second-largest producer of rice (131 million tonnes) next to China (197 million tonnes). The rice productivity in India is 3.37 t ha^{-1} against the world average of 4.25 t ha^{-1} (Sangeetha *et al*., 2015). Transplanted rice cultivation is the most popular and traditional way of growing rice. However, this method incurs high labour cost in seedbed preparation, sowing in nursery, uprooting, transplanting in the main field etc. Moreover, repeated puddling adversely affects the soil physical properties by dismantling soil aggregates, reduces permeability in sub surface layers and form hard pans at shallow depths. (Sharma *et al.*, 2008).

Water is a costly input worldwide and the water use efficiency (WUE) of rice is very low and rice crop consumes about 5000 litres of water to produce one kg of grain. The direct seeding is another method of rice establishment that avoids some basic operations like nursery raising, uprooting of seedlings, puddling, transplanting, maintaining standing water and thereby reduces labour requirement (Pepsico International, 2011). Direct seeded rice could be an alternative to transplanted rice which could produce almost the same or higher yield with the minimal use of water, production input and also sustainable in long run.

Among the pulse crop grown in Assam, greengram is a popular crop among the farmers and it is grown mostly in *kharif* season (mid-August-first of September). In some pockets, it is also grown in February - March as summer pulse. Assam experiences heavy monsoon rains throughout the *kharif* season and there is a record of crop failures due to water stagnation in the standing crop just after sowing or at the vegetative stage. Therefore draining of water from the field is very much essential for saving the crop from water stagnation. Broad bed furrow (BBF) method is an emerging practice of land configuration in *rainfed* farming system which acts as *in-situ* moisture conservation as well as help in draining out excess rain water in furrows. Considering the importance of water, conservation of moisture and saving of cost, a trial was conducted at Biswanath College of Agriculture, Assam Agricultural University, Biswanath Chariali, Assam during *autumn* and *kharif* season of 2016 and 2017 to study the influence of moisture conservation practices of land configuration in terms of BBF along with crop residue incorporation on direct seeded *ahu* rice-greengram cropping sequence for evaluating the WUE and yield performance of the crop sequence.

Materials and Methods

The field experiment was conducted for two years (2016 & 2017) in sequence starting with direct seeded rice followed by greengram. The experiment was conducted at BN College of Agriculture, Biswanath Chariali of Assam Agricultural University, Assam. The weather condition at Biswanath Chariali is hot and humid during summer and cold and moist during winter. During 2016, in *ahu* rice growing season March-July, (12^{th} SMW to 29^{th} SMW) total rainfall of 1112.5 mm was received in 67 rainy days. In 2017, total rainfall of 1308.1 mm was received in 63 rainy days. Average maximum temperature range was 24.9 °C to 33.6 °C during 2016 and 25.4 °C to 33.2 °C during 2017 and the minimum temperature range was 17.0 °C to 26.7 °C and 15.8 °C to 26.3 °C during 2016 and 2017, respectively.

During greengram growing period of 2016 and 2017 (33^{rd} SMW to 43^{rd} SMW), total rainfall received was 480.4 mm and 526.4 mm against the total evaporation of 226.6 mm and 207.8 mm respectively. During 2016, the mean maximum and minimum temperature ranged between 29.9 °C to 34.3 °C and 21.2 °C to 26.9 °C respectively while in 2017, the mean maximum temperature ranged between 27.7 °C to 34.1 °C and minimum temperature ranged between 19.1 °C to 25.9 °C. The number of rainy days during greengram growing period was 25 and 27 in 2016 and 2017, respectively.

The soil of the experiment field was sandy loam with an initial pH of 5.2 and 5.4 in 2016 and 2017, respectively. The organic carbon content was 0.59% and the initial available soil nitrogen, phosphorus and potash were in the range of low (259.10 $kgha^{-1}$), medium (25.65 $kgha^{-1}$) and low (112.30 $kgha^{-1}$). Two different sizes of BBF consisting 60 cm and 120 cm width with a gap of 30 cm size furrow in between beds were studied. The treatments were flat bed with crop residue incorporation (M_1), Flat bed with no residue incorporation (M_2), BBF 60-30 cm with residue incorporation (M_3), BBF 60-30 cm without residue incorporation (M_4), BBF 120-30 cm with crop residue incorporation (M_5) and BBF 60-30 cm without crop residue incorporation (M_6). The experiment was laid out in randomized block design with 4 replications. The plots were ploughed by tractor-drawn plough followed by one harrowing. Laddering was done properly to retain water uniformly in the field. Weeds and other stubbles were removed from the field at the time of final land preparation. The broad bed furrows were prepared manually as per treatment assigned. After harvest of direct seeded *ahu* rice, plots were prepared manually, without breaking the broad bed furrows for maintaining the incorporation of crop residues as per treatments and greengram was grown.

The rice crop was sown in line with 20 cm spacing. In 60-30 cm bed, 3 rows of rice were allocated and in 120-30 cm bed, 6 rows of rice were allocated. The greengram crop was sown in 30 cm spacing in all the BBF and flat beds. Recommended doses of fertilizers were applied in both rice and greengram. The variety used for direct seeded rice was *"Inglongkiri"* which was developed by Regional Agricultural Research Station, Assam Agricultural University Diphu, having an average duration of 115-120 days. For greengram, the variety SG-1 (*Pratap*) was selected for the study.

For soil moisture content, soil samples were collected from 0-15, 15-30, 30-45 and 45-60 cm depth at 30 days interval from sowing to harvesting of each crop.

The moisture content was determined gravimetrically by using the formula:

$$\omega = \frac{M_{wet} - M_{dry}}{M_{dry}} \text{ X } 100\% \quad (1)$$

where, ω = Gravimetric moisture content (%); M_{wet} = Mass of wet soil (g); M_{dry} = Mass of oven dry soil (g).

Water requirement (WR) or water use by the crop was calculated by using the following formula (Sarma, 2020):

$$WR = I + ER + S \quad (2)$$

where, I=Irrigation (for rainfed crops water applied through irrigation is considered as zero); ER=Effective rainfall; S=Soil profile water contribution.

Soil profile contribution (S) was calculated by using the following formula:

$$S = \sum_{i=1}^{n} \frac{\omega_{bi} - \omega_{ei}}{100} \text{ x } ASG_i \text{ x } D_i \quad (3)$$

where, ω_{bi}=Moisture percentage at the beginning of the season at i^{th} layer; ω_{ei}=Moisture percentage at the end of the season at i^{th} layer; ASG_i=Apparent specific gravity of the i^{th} layer of soil; D_i=Depth of the i^{th} layer in the root zone; n=Number of the soil layer in the root zone D.

Field water use efficiency

Field water use efficiency (FWUE) of the crop for different treatments were calculated as follows:

$$\text{FWUE (kg/ha-mm)} = \frac{\text{Weight of seed (kg ha}^{-1}\text{)}}{\text{Total water used (mm)}} \quad (4)$$

Results and Discussion

Effect of moisture conservation practices on direct seeded rice

Yield attributes : The yield attributes *viz.* number of effective panicles m^{-2} and grains $panicle^{-1}$ of direct seeded *ahu* rice due to different soil moisture conservation practices differed significantly (Table 1). The panicles m^{-2} under BBF 60-30 cm with (113.00 and 117.69 in 2016 and 2017) and without residue (112.69 in 2016 and 113.75 in 2017) which was at par with BBF 120-30 cm with residue (109.56 panicles m^{-2} in 2016 and 113.63 in 2017). The BBF 60-30 cm with residue incorporation resulted in significantly higher values over both flat bed with or without residue incorporation.

The number of grains panicle^{-1} in 2016, both with BBF 60-30 cm and BBF 120-30 cm with and without residue incorporation were statistically at par. But in 2017, BBF 60-30 cm with residue incorporation produced significantly higher number of grains panicle^{-1} over all other moisture conservation practices (Table 1). The higher number of effective panicles m^{-2} and grains panicle^{-1} under BBF 60-30 cm and BBF 120-30 cm with residue integration over flatbed may be attributable to the crop's better growth as a result of increased water conservation and retention in the furrows during dry spells. Similar results with higher number of grains panicle^{-1} were reported by Kaur and Dhaliwal, 2015 and Hobbs and Gupta, 2003 in rice with raised bed sowing method.

Grain and straw yield: In 2016, the grain yield under BBF 60-30 cm with residue (23.43 q ha^{-1}) and without residue (22.72 q ha^{-1}) and BBF 120-30 cm with residue (22.81 q ha^{-1}) incorporation were statistically at par. In 2017, BBF 60-30 cm with residue (25.70 q ha^{-1}) significantly out yielded all other treatments (Table 2). The pooled data over the years, revealed that the effect of both the BBF 60-30 cm (24.56 q ha^{-1}) and BBF 120-30 cm with residue (23.47 q ha^{-1}) incorporation were at par. BBF 60-30cm with residue (24.56 q ha^{-1}) produced significantly higher grain yield over rest of the treatments (Table 2). The results showed 11.0% more yield under BBF 60-30 cm with residue incorporation than under flatbed without residue, which was mainly due to higher number of effective panicles m^{-2} and grains panicle^{-1} of the crop. According to Singh *et al.*, the permanent bed sowing method increased the production of wheat by 60% and the yield of rice by 33% in a rice-wheat cropping system (2011).

Though no significant changes were observed in straw yield of direct seeded *ahu* rice due to various soil moisture conservation practices in the year 2016 and it differed significantly in the year 2017 (Table 2). The treatment BBF 60-30 cm with residue incorporation produced the highest straw yield, which was significantly higher over all the treatments. The increase in grain yield and straw yield in wheat crop grown after maize due to the residual effect of crop residue as mulching, was also reported by Sharma *et al*., 2010.

Water use and water use efficiency of direct seeded *ahu* rice

The soil moisture conservation practices *viz;* BBF 60-30 cm and 120-30 cm both with and without residue resulted in higher water used was recorded by the crop in both the year of experimentation over the flat bed method of sowing (Table 3). During both the year, the highest water used was recorded under BBF 60-30 cm with residue (380.3 mm in 2016 and 385.6 in 2017) lowest was recorded under flatbed without residue incorporation (369.1 in 2016 and 367.8 mm in 2017 respectively). During both the year, the FWUE (Table 3) was also considerably more under the treatment BBF 60-30 cm with residue (6.16 kg ha^{-1} mm, in 2016 and 6.66 kg ha^{-1} mm in 2017).

Table 1: Effect of moisture conservation practices on yield attributes of direct seeded *ahu* rice

Treatment	Effective panicle m^{-2}		Grains panicle^{-1}		1000-grain weight (g)		Length of panicle (cm)	
	2016	2017	2016	2017	2016	2017	2016	2017
M_1: Flatbed with residue	106.35	108.19	91.33	99.13	23.60	24.05	23.14	24.56
M_2: Flatbed without residue	105.63	107.38	92.62	94.69	23.80	23.80	23.37	24.00
M_3: BBF 60-30 cm with residue	113.00	117.69	98.35	108.38	24.01	23.80	24.21	24.72
M_4: BBF 60-30 cm without residue	112.69	113.75	97.63	100.13	23.91	23.81	24.15	23.81
M_5: BBF 120-30 cm with residue	109.56	113.63	95.10	102.44	23.70	23.90	23.73	24.60
M_6: BBF120-30 cm without residue	108.38	110.38	94.25	97.63	23.82	23.81	23.80	24.10
SEm$\pm$	1.82	2.22	1.80	1.50	0.22	0.15	0.29	0.31
CD at 5%	5.48	6.69	5.43	4.41	NS	NS	NS	NS

Table 2: Effect of moisture conservation practices on grain, straw yield and harvest index of direct seeded *ahu* rice

Treatment	Grain yield (q ha^{-1})			Straw yield (q ha^{-1})			Harvest index (%)	
	2016	2017	Pooled	2016	2017	Pooled	2016	2017
M_1: Flatbed with residue	21.85	23.69	22.77	37.94	39.88	38.91	36.55	37.27
M_2 : Flatbed without residue	21.90	22.38	22.14	37.47	37.88	37.67	36.88	37.13
M_3: BBF with residue 60-30 cm	23.43	25.70	24.56	38.70	42.60	40.65	37.71	37.62
M_4: BBF without residue 60-30 cm	22.72	23.31	23.01	38.04	39.55	38.79	36.96	37.08
M_5: BBF with residue 120-30 cm	22.81	24.14	23.47	37.97	40.13	39.05	37.43	37.56
M_6: BBF without residue 120-30 cm	22.31	23.06	22.68	37.28	39.03	38.15	37.95	37.13
SEm$\pm$	0.27	0.31	0.33	0.84	0.80	0.64	0.46	0.49
CD at 5%	0.74	0.95	1.24	NS	2.40	2.31	NS	NS

Effect of moisture conservation practices on greengram

Yield attributes: The treatment BBF 60-30 cm both with and without residue incorporation produced significantly higher number of clusters plant $^{-1}$ over rest of the treatments during both 2016 and 2017 (Table 4). In respect to number of pods cluster $^{-1}$ in 2016, BBF 60-30 cm and BBF 120-30 cm with and without residue incorporation showed at par effect but significantly higher over both flatbed methods (Table 4). While in 2017, the effect of BBF 60-30 cm with and without residue incorporation and BBF 120-30 cm without residue incorporation on such number of pod cluster^{-1} were significantly higher over rest of the treatments. During both the years, higher values were recorded in respect of number of seeds pod^{-1} and 1000 seed weight (Table 4) under BBF 60-30 cm with residue incorporation and the lowest values were observed under the flatbed without residue incorporation. Better crop growth coupled with optimum moisture availability due to the adequate drainage of excess rain water through the provision of furrows in BBF methods might have resulted in better yield attributing characters compared to flatbed sowing. A similar result of increased yield attributes of greengram *viz.*, number of clusters plant^{-1} and pod cluster^{-1} due to the land configuration of BBF compared to flatbed method was also reported by Tomar *et al.,* 2013. Increased number of pods under the raised bed in chickpea was also reported by Shrivastava *et al.,* 2018.

Seed and stover yield: Both the treatments, BBF 60-30 cm and BBF 120-30 cm with and without residue incorporation resulted in statistically similar seed and stover yield and produced significantly higher values over the flat methods with and without residue incorporation (Table 5). The highest seed yield (9.58 q ha^{-1} in 2016 and 10.63 q ha^{-1} in 2017) and stover yield (27.62 q ha^{-1} in 2016 and 29.26 q ha^{-1}in 2017) were recorded with the treatment BBF 60-30 cm with residue followed by BBF 60-30 cm without residue and BBF 120-30 cm with and without residue incorporation. The flat bed method of sowing recorded significantly the lower seed and stover yields in both the year.

The data pooled over the years (Table 5) also revealed that the treatment BBF 60-30 cm with residue (10.10 q ha^{-1}) followed by BBF 60-30 cm without residue (9.77 q ha^{-1}) incorporation out yielded rest of the treatments, in respect to seed and stover

Table 3: Effect of moisture conservation practices on water use and field WUE of direct seeded rice

Treatment	Water use (mm)		Field WUE (Kg/ha-mm)	
	2016	2017	2016	2017
M_1: Flat bed with residue	369.6	374.1	5.91	6.33
M_2: Flat bed without residue	369.1	367.4	5.93	6.08
M_3: BBF with residue 60-30 cm	380.3	385.6	6.16	6.66
M_4: BBF without residue 60-30 cm	379.6	372.9	5.87	6.25
M_5: BBF with residue 120-30 cm	380.2	382.4	5.97	6.31
M_6: BBF without residue 120-30 cm	380.1	371.1	6.00	6.21

Table 4: Effect of soil moisture conservation practices and crop sequences on primary branch and yield attributing characters of greengram

Treatment	Primary branches plant^{-1}		Clusters plant^{-1}		Pods cluster^{-1}		Length of pod (cm)		Seeds pod^{-1}		1000 seed weight (g)	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Moisture conservation practices												
M_1: Flat bed with residue	0.53	0.58	2.35	2.53	2.09	2.23	7.62	7.93	7.94	7.32	30.84	30.98
M_2 : Flatbed without residue	0.50	0.54	2.33	2.41	2.07	2.13	7.39	7.88	7.81	7.17	30.78	30.98
M_3: BBF with residue 60-30 cm	0.66	0.73	2.59	2.75	2.33	2.51	7.88	8.02	8.84	8.80	30.84	31.07
M_4: BBF without residue 60-30cm	0.61	0.65	2.47	2.67	2.23	2.36	7.72	7.98	8.56	7.94	30.78	30.42
M_5: BBF with residue 120-30 cm	0.65	0.67	2.56	2.68	2.33	2.45	7.70	8.02	8.72	8.16	31.34	31.35
M_6: BBF without residue 120-30 cm	0.60	0.63	2.45	2.53	2.21	2.37	7.67	7.83	8.45	7.84	31.08	31.13
SEm±	0.02	0.03	0.06	0.07	0.06	0.07	0.16	0.12	0.30	0.29	0.46	0.31
CD at 5%	0.07	0.09	0.17	0.20	0.17	0.20	NS	NS	NS	0.87	NS	NS

yield. BBF 60-30 cm with residue incorporation resulted in higher seed and stover yields which was 35.6% and 39.3% over the flatbed methods with or without residue incorporation. The higher yield attributes like number of clusters plant^{-1}, pods cluster^{-1} and seeds pods^{-1} under the treatment BBF 60-30 cm with and without residue incorporation might have attributed to produce higher seed and stover yield of the crop. Drainage of excess rain water through the broad bed furrows led to adequate aeration even during the rainy days (25 days in 2016 and 27 days in 2017). It saved the crop from oxygen depletion in the root zone by reducing water stagnation in the crop field. This might have resulted in significantly higher seed and stover yields under the treatment BBF. Increased seed and stover yield of chickpea and safflower by 12.5% and 10.7% in BBF planting over traditional flatbed method were also reported by Khambalkar *et al.,* 2014. In 2017, harvest index (Table 5) varied significantly and BBF 60-30 cm and BBF 120-30 cm with and without residue incorporation resulted in similar effect and all being significantly higher over flatbed methods with or without residue incorporation. Higher biological yield of wheat from land configuration treatment as compared to the conventional system was also reported by Jat and Singh (2003).

Water use and water use efficiency of *kharif* greengram: Data presented in Table 6 revealed that during both the years, the higher values of water used by *kharif* greengram were recorded with the treatment BBF 120-30 cm with residue incorporation (129.5 mm and 132.9 mm in 2016 and 2017). This was followed by BBF 120-30 cm without residue incorporation (128.1 mm and 130.1 mm in 2016 and 2017) and BBF 60-30 cm with residue incorporation (123.3 mm and 127.5 mm in 2016 and 2017). The lowest water used by *kharif* greengram was recorded under the treatment flatbed sowing with no residue incorporation (101.2 mm and 105.8 mm in 2016 and 2017) during both the year. The furrows of the broad beds facilitated adequate drainage during the period of excess rainfall and created more favorable edaphic environment for availability and absorption of moisture by the crop, that might have resulted in higher water use by the crop under these treatments. Similar result of water used by cluster bean in cluster bean-wheat sequence was reported in a field trial at CCS Haryana Agricultural University Ranjana *et al. (*2016).

Higher field water use efficiency of greengram (Table 6) was observed under the treatment BBF 60-30 cm with residue (7.76 and 8.33 kgha^{-1}mm^{-1}, in 2016 and 2017) followed by BBF 60-30 cm without residue incorporation (7.70 and 8.00 kg ha^{-1}mm^{-1}, in 2016 and 2017) compared to other treatments. Here also, the lowest values were recorded under flatbed sowing with no residue incorporation (6.55 and 6.59 kg ha^{-1}mm^{-1} in 2016 and 2017) during both the year. The higher seed yield of greengram (Table 5) associated with the treatments might have attributed to the higher water use efficiency of the crop. Similar interpretations of Higher WUE in wheat crop were also reported by Idnani and Kumar (2013).

Table 5: Effect of soil moisture conservation practices on seed and stover yield and harvest index of greengram

Treatment	Seed yield (q ha^{-1})			Stover yield (q ha^{-1})			Harvest Index (%)	
	2016	2017	Pooled	2016	2017	pooled	2016	2017
M_1: Flat bed with residue	6.73	7.45	7.09	19.06	22.08	20.57	26.09	25.22
M_2 : Flat bed without residue	6.63	6.98	6.82	18.90	21.61	20.26	25.96	24.41
M_3: BBF 60-30cm with residue	9.58	10.63	10.10	27.62	29.26	28.44	25.75	26.64
M_4: BBF 60-30 cm without residue	9.44	10.11	9.77	26.10	28.11	27.10	26.56	26.45
M_5: BBF 120-30 with residue	9.04	9.69	9.36	24.96	27.99	26.47	26.58	25.71
M_6: BBF 120-30 without residue	8.95	9.33	9.14	24.75	27.11	25.93	26.55	25.60
SEm$\pm$	0.36	0.41	0.19	0.97	0.75	0.41	0.56	0.47
CD (*P=0.05*)	1.09	1.23	0.62	2.91	2.25	1.23	NS	1.40

Table 6: Effect of moisture conservation practices on water use and field WUE of greengram

Treatment	Water use (mm)		Field WUE (kg/ha-mm)	
	2016	2017	2016	2017
M_1: Flat bed with residue	102.5	106.8	6.56	6.97
M_2 : Flat bed without residue	101.2	105.8	6.55	6.59
M_3: BBF with residue 60-30 cm	123.3	127.5	7.76	8.33
M_4: BBF without residue 60-30 cm	122.5	126.3	7.70	8.00
M_5: BBF with residue 120-30 cm	129.5	132.9	6.98	7.29
M_6: BBF without residue 120-30 cm	128.1	130.1	6.98	7.17

Equivalent yield and economics: The equivalent yield of the rice-greengram sequence was calculated (Table 7) and results showed that in both year of experimentation, the BBF method of moisture conservation irrespective of the size of the bed (60-30 cm and 120-30 cm) was significantly better than the flatbed. The pooled data over the years also showed the same trend. Between the BBF (60-30 cm bed and 120-30 cm bed), the net return and B:C ratio was more in BBF 120-30 cm size bed due to comparatively better yield and less cost of cultivation in terms of man-days required in preparing bed as number of furrow requirement is less in BBF 120-30 cm as compared to BBF 60-30 cm bed. Although cost of cultivation is more in residue incorporation treatments as compared to no residue incorporation, the cost was compensated by the higher yield obtained in both the crop of rice and greengram. The better yield of the rice and greengram particularly in second year was perhaps due to the better retention of moisture in rainless period by the residue which acted as mulch for better conservation of moisture.

Conclusion

Higher grain yield of rice was recorded under BBF 60-30 cm with and without residues and BBF 120-30 cm with residue incorporation. Both BBF 60-30 cm and BBF 120-30 cm resulted better over rest of the treatments. Similar trend of superiority of BBF over flatbed was observed in yield attributes of *kharif* greengram. The seed and stover yield of greengram due to both the BBF with or without residue was at par in effect and being significantly higher over flatbed method of moisture conservation practices. Pooled data also showed superiority of BBF irrespective of the size of the beds over flatbeds. We can conclude that BBF method of moisture conservation practices along with residue incorporation is suitable practices for better growth, and yield as well as net income of farmers. During *kharif* greengram, the furrows of the BBF helps in draining of excess rainfall during monsoon period (July to Sept) in Assam thereby saved the crop from water stagnation. From economic point of view BBF 120-30 cm bed size is the better although yield is somewhat less than the BBF 60-30 cm as cost of cultivation is less in furrow preparation.

References

Hobbs PR and Gupta RK. 2003. Rice-wheat cropping systems in the Indo-Gangetic plains: Issues of water productivity in relation to new resource conservation technologies. *Water productivity in Agriculture: Limits and opportunities for improvement.* CABI, Walling Ford, UK, 239-253.

Idnani LK and Kumar A. 2013. Performance of heat under different irrigation schedules and sowing methods. *Indian Journal of Agricultural Science,* 83(1): 37-40.

Jat M, Singh S, Rai HK, Chhokar RS, Sharma SK and Gupta RK. 2005. Furrow irrigated raised bed (FIRB) planting technique for diversification of rice-wheat system in Indo-Gangetic Plain. *Japan Association for International Collaboration of Agriculture and Forestry,* 28(1): 25-42.

Kaur S and Dhaliwal LK. 2015. Yield and yield contributing characteristics of wheat under bed planting method. *International Journal of Farm Sciences,* 5(3): 1-10.

Khambalkar KP, Nage SM, Rathod CM, Gajakos AV and Shilpadahatonde. 2014. Mechanical sowing of safflower on broad bed furrow. *Australian Journal of Agricultural Engineering,* 1(5): 184-187.

Pepsico International. 2011. Direct seeding of paddy. The work of pepsico reported in India water *portal. http:/ww.india.waterportal.org/pst/6754.*

Ranjana GA, Dhindwal AS and Nanwal RK. 2016. Irrigation scheduling and crop establishment techniques in cluster bean-wheat sequence under semi-arid conditions of India-a review. *Annals of Agricultural Research New series,* 37 (4): 335-346.

Sangeetha C and Baskar P. 2015. Influence of different crop establishment methods on productivity of rice- A review. *Agricultural review,* 36 (2): 113-124.

Table 7: Rice equivalent yield and economics of the system

Treatment	REY (q ha^{-1})			Cost of cultivation (Rs ha^{-1})		Gross return (Rs ha^{-1})		Net return (Rs ha^{-1})		B:C ratio	
	2016	2017	pooled	2016	2017	2016	2017	2016	2017	2016	2017
M_1: Flat bed with residue	51.42	57.44	54.43	42530	44030	56562	63184	14032	19154	1.32	1.43
M_2 : Flat bed without residue	52.21	54.03	53.12	41030	41030	57431	59433	16401	18403	1.39	1.44
M_3: BBF 60-30 cm with residue	64.47	69.62	67.04	45530	47030	70917	76582	25387	29552	1.55	1.62
M_4: BBF 60-30 cm without residue	63.20	65.70	64.45	44030	44030	69520	72270	25490	28240	1.57	1.64
M_5: BBF 120-30 cm with residue	65.54	72.42	68.98	44530	46030	72094	79662	27564	33632	1.61	1.73
M_6: BBF 120-30 without residue	66.27	68.94	67.60	43030	43030	72897	75834	29867	32804	1.69	1.76
SEm$\pm$	2.47	2.74	2.14	-	-	-	-	-	-	-	-
CD at 5%	7.45	8.24	7.81	-	-	-	-	-	-	-	-

(Note: Price of rice: Rs. 1100/q and price of greengram: Rs. 5000/q)

Sharma SN and Prasad R. 2008. Effect of crop residue management on the production and agronomic nitrogen efficiency in a rice-wheat cropping system. *Journal of plant nutrition and soil science*, 171(2) : 295-330.

Sharma AR, Singh R, Dhyani SK and Dube RK. 2010. Moisture conservation and nitrogen recycling through legume mulching in *rainfed* maize-wheat system. *Nutrient Cycling in Agroecosystems,* 87: 187-197.

Singh YP, Singh S, Singh AK and Pawar B. 2011. Influence of wheat establishment techniques and previous *kharif* season crops on productivity, profitability, water use efficiency, energy indices and soil properties. *Agricultural research*. ISSN 2249-720X.

Shrivastava YR, Khare and DK Pahalwan. 2018. Performance of chickpea under raised bed planting in Vertisols in Central India. *International Journal of Current Microbiology and Applied Sciences, 7(3)*: 810-812.

Tomar SS, Sharma KK and Pachlamiya NK. 2013. Management of soil and water resources towards enhanced agricultural profitability. *Jawaharlal Nehru Krishi Viswavidyalaya Research Journal,* 47(2): 116-140.